Japan's Science and Engineering Pipeline: Structure, Policies, and Trends

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The U.S. Science Policy community has, in recent years, developed a new awareness of the scale and capabilities of the Japanese science and engineering work force. Though the Japanese population is less that half the size of the American, Japanese higher education graduates as many engineers annually as the U.S., and about half as many scientists. In selecting their students, Japan's universities and colleges can draw from an exceptionally well-prepared crop of high school graduates. Comparative studies of math and science achievement indicate that the overall academic quality of Japanese education through high school is superior to American education, and that much larger proportions of the Japanese school and university age cohorts pursue studies in subjects conducive to an understanding of scientific and technical matters. It may be that these characteristics of the Japanese work force are an important part of the explanation for contemporary Japan's competitiveness in high-technology innovation, production, and marketing.

The apparent edge of the Japanese work force is an emerging trend, based on major structural reforms in the education system that took place after World War II followed by steady

implementation and modificaton of these reforms. In this paper, I will highlight tha principal differences between the structure of U.S. and Japanese education that account for Japan's work force edge.

The Japanese system has its weaknesses, many of which are readily acknowledged by Japan's leaders (National Council on Education Reform, 1985, 1986, 1987; Amano, 1986). Education at the school level is too monolithic and competitive, and thus young people learn what they must to compete in the exams but lack the leisure to pursue unique interests and develop their creative powers. Higher education is not as challenging as it might be, at least to the average student. And both graduate and post-graduate education require more support and organization. Many of these problems are being addressed by a current wave of educational reform, which also will be reviewed.

The Origins of Japanese Work Force Policies

The foundations of Japanese work force policies go back over one hundred years to that fertile period when a youthful group of aristocrats led the revolution of 1868 deposing the old Tokugawa shogunate and establishing the Meiji state. This group while firmly committed to Eastern morality recognized Japan's backward state in Western technology. Accordingly, they introduced a wide-ranging set of policies to narrow the gap.

Missions were sent abroad to examine Western institutions,

and within a few years a new mass educational system was launched which included courses in Western science and mathematics from the first grades of primary school. Western scholars were invited to Japan to help establish secondary schools and universities and teach the most promising youth, who within a decade were sufficiently knowledgeable to take the places of their mentors. Drawing largely on indigenous talent, in 1886 the Japanese government established the first Imperial University. This institution was modeled on continental universities with the traditional faculties of law, philosophy (bungakubu), science, and medicine; but reflecting the practical disposition of the Japanese leaders, faculties of engineering and agriculture were also included.

Attendance at the Imperial University was accorded tremendous prestige, and a sure ticket to an elite career either in government or the emerging business sector. Hence the desire to enter the Imperial University was widespread. In 1987 a second Imperial University was established in Kyoto.

In the decades that followed, the government proceeded to fill out the system with a diverse array of secondary and tertiary institutions. Government policy was aimed at fulfilling perceived manpower needs while achieving regional balance and maintaining quality. At the secondary level, a number of different tracks were structured: a narrow academic track through middle schools and higher schools to university entrance, a side track off of the above starting with middle school graduation to

technical colleges and teacher's education colleges, another track beginning with primary school graduation into vocational and/or domestic training, and yet other tracks leading to teacher education, military training, and other options. Most of the secondary schools were segregated by sex, and girls were not elibible for admission to universities.

Education and the Dualistic Employment System

Prior to Japan's modernization drive, agricultural was the dominant economic pursuit in Japan. The small class of samurai (about five percent of the labor force) occupied positions in feudal bureacracies as tax collectors, civil works administrators, legalists, and scribes. Hereditary status and performance in fief schools were the basis for the feudal appointments.

To effect development, it is sometime said that the Japanese planners approached their task in reverse order, building their schools first and then their factories. Indeed it was certainly the case that the early universities and technical institutes were established prior to significant industrial development. More commonly, those specialized institutions receiving government funds were established to support emerging industrial efforts. Partly because of the close ties between educational and industrial planning, success in the educational sector came to be recognized as a precondition for recruitment to key positions in the emerging industrial sector. From early on,

graduation from the law school of the Imperial Universities of Tokyo or Kyoto was recognized as a prerequisite for employment in the higher civil service. Over time other such linkages were established.

During the first decades of development, light industries and small retail establishments were the major employers and their demands for specialized skills were modest. But from the early twentieth century, the number of medium and large establishments rapidly increased, and the demand for skilled and technically competent manpower picked up. Initially employers recruited from the full pool of capable manpower, but following World War I key industrial leaders began to articulate a familistic ideology of labor relations wherein managers and workers would enter into a contract of mutual commitments.

As this ideology took hold, employers became more disposed to seek new recruits fresh out of school and to eschew recruiting employees from the ranks of their competitors. Over the ensuing years, the details of the lifetime employment system practiced by most large Japanese organizations were elaborated. Two features having important bearing on S/T workforce policies are (1) the condition that employment begin straight from school, and (2) employees are recruited to work in all parts of their organization rather than on a particular task. Partly due to this second feature, employers prefer broadly trained recruits (arts majors with some understanding of science and technology and vice versa). Following from this second condition also are

the essential identical beginning salaries offered all recruits, regardless of academic specialization, and the caution employers exhibit in recruiting highly specialized graduates with advanced professional skills; employers would prefer to see their staff acquire such expertise on the job rather than at a university.

With the lifetime approach to employment, employer concern for avoiding recruitment mistakes increased. To insure high quality recruits, each employer sought to establish close and favored relations with a small number of feeder schools. The first preference of employers was for the most highly regarded school. For university level recruits, this meant that most employers hoped to obtain their recruits from the Imperial Universities and the top private institutions. In the face of so many anxious employers, these universities tended to ration out their graduates (through faculty recommendations) so as to satisfy as many employers as possible.

Employer emphasis on educational qualifications also had a profound impact on the approach of young people to career preparation. Both the need to do well in school and to gain admission to a well-placed terminal institution (collegiate or otherwise) became more salient. The close links of education with employment in the expanding modern sector of large and medium scale organization became a spur both to seriousness in school work and to the rapid expansion of educational institutions.

Educational Expansion

Initially, the national government exercised retraint in the establishment of universities, and through 1918 only eight had been established, each accorded funds and prestige in the order of its founding. But in response to the post WWI economic boom and the keen popular demand for higher education, additional public institutions were established.

Within the framework of government regulations on educational standards, private schools were allowed to be established. Over time, large numbers were founded, often to complement the offerings of public institutions: for example, at the post-secondary level, while government schools tended to stress technical specialties, many private schools offered courses in foreign languages, literature, office skills and other subjects that were of interest to the growing middle class. Because of limited funds and a disadvantageous position in placing graduates in prestigious government jobs, most private institutions were not as highly regarded as the public institutions. By the time of World War II, approximately 40 percent of the secondary level age cohort and ten percent of the tertiary level age cohort were enrolled in some type of institution. About half at each level were in private institutions (Anderson, 1975; Ministry of Education, 1980).

Over time, the successful pursuit of formal education came to be viewed as the means to a secure job in a large organization of either the public or private sector. Top universities sent

their graduates to elite positions in government and business. Middle-rank universities supplied the next echelon, and so on down the hierarchy. During the depressed economic circumstances of the thirties, these education employment linkages were somewhat disturbed; nevertheless the myth prevailed that success in education guaranteed success in a career.

In sum, the central government exercised strong leadership in the establishment of the "old system." The result was a complex system with multiple layers or tracks and multiple sectors of sponsorship (hence sometimes described as a "multi-layer multi-sector" or ML-MS system) (Amano, 1979). Some noteworthy features influencing the S/T pipeline were:

(a) The hierarchy in institutional prestige

(b) Several nodes of terminal education beyond which the individual had to leave the formal educational system.

(c) Segregation of tracks for males and females.

Postwar reforms described below led to changes in these features.

The New System

Following World War II, Japan was occupied by the allied forces who, under the leadership of General Douglas MacArthur of the United States, promoted various reforms to "democratize and demilitarize" the nation. Education was a key area of reform, and here the overall thrust was to simplify and Americanize the system through expanding opportunities and eliminating terminal

tracks. Also, the Occupation proposed decentralization of control. In terms of structure, the old ML-MS system was to be transformed into a "new 6-3-3-4 coeducational system" with nine years of compulsory schooling (six at elementary and three at lower secondary), with further opportunity for three years of upper secondary and four years of university education.

These proposals implied major restructuring and expansion at a time when Japan was only slowly recovering from the ravages of a long and exhausting war. The process of implementation stretched into the mid-fifties. In the sections below we will summarize several of the resultant changes, highlighting both the contrast of Japan's "new system" with its "old system" and the main outlines of the American system.

Centralization. A key proposal of the Occupation was to shift control and support of the educational system from the central Ministry of Education to prefectural (47 in Japan) and district levels. For the governance of public universities, boards of trustees were proposed but soon ruled out; in the absence of other proposals, the public universities became self-governing bodies, though dependent on the national and (in some instances) local governments for financial and administrative support. For the governance of schools, locally elected school boards were actually tried for several years, and then due to "excess" politicization the electoral principle was replaced by appointment from above. The change from the electoral to appointment principle has effectively shifted the locus of school

politics to the prefectural level; one consequence has been to reduce the complications in consolidating local districts as the size of school-aged cohorts have change.

Currently Japan has 50 prefectural level school boards (47 prefectures plus one each for the urban areas of Tokyo, Kyoto, and Osaka) and about 500 local school boards; all members are appointed. In contrast, in the U.S. a few states have state-level school boards while the majority place control of public education in the hands of local school boards, many of which are elected. Currently, there are some 16,000 school boards in the U.S.

Finance. Similarly, decentralized revenue generation was proposed by the Occupation, but in view of the general postwar conditior of destitution this concept was essentially abandoned. At the tertiary level, the central government assumed responsibility for most of the public institutions, while private institutions were left to obtain their revenues in whatever manner possible. At the school level, the new tax laws provided local and prefectural governments with new revenue sources that were sufficient to cover part of the costs of public education. But in view of the postwar Constitution's assertion that the national government should guarantee equal education for all through the ninth grade, special budget-equalizing regulations were devised. These regulations required the central government to supplement the educational budgets of the poorer prefectures up to that level sufficient to realize a minimal common

educational standard, including provisions for supplementary benefits to schools in isolated areas (islands, mountainous areas) or areas with large minority populations (Ministry of Education, 1984).

Recent analyses of compulsory level educational expenditures in Japan indicate no more than a 60 percent variation in the average per pupil expenditure across prefectures, and some inner-city schools that receive large numbers of burakimin are funded well above the national average (Mombusho, Kyoiku Nenkan, 1986). In the U.S., the Constitution asserts that education is a local responsiblility. The variation across states is in excess of 200 percent (Center for Educational Statistics, 1986), and between school districts there is even greater disparity; inner-city schools are often disadvantaged.

Teachers. Equality of educational finance has had an important impact on the status and welfare of Japan's teachers. In response to the rapid postwar emergence of a militant All-Japan Teachers Union (Nikkyoso) which participated in general strikes and sought to enter into collective bargaining with the central government over salaries and working conditions, a law was passed making teachers the employees of local governments. Nevertheless, in order for the central government to realize equal education across prefectures, it relies on a uniform salary schedule for determining the amount of subsidy it should provide to local educational budgets. This salary schedule conforms to the principles for most public employees in Japan with a modest

entry-level salary and steady annual seniority increments and substantial retirement benefits. Differences in educational attainment and level of teaching (compulsory versus high school) are rewarded with small increments. The annual increments, designed to reward loyal service and increasing personal needs as the teacher acquires a family, mean that teachers with 20 years of service receive nearly three times the real income of entering teachers.

Due to this uniform schedule (once adjustments are made for age and school level), teachers throughout Japan can look forward to an essentially identical lifetime income cycle. For most of the postwar period, the level of teacher pay was fixed at a level correspondent with that for local officials, and since 1975 it has actually been raised above that level. Thus from an economic standpoint, teaching in Japan is an attractive job. Japanese school authorities report a surplus of qualified candidates for openings, even for math and science teaching positions. Surveys indicate that nearly 100 per cent of Japan's teachers have the proper qualification for the subject areas and levels they teach (U.S. Office of Education, 1987, pp. 15ff).

In contrast, teacher pay in the U.S. varies widely by location. A recent study indicates that average teacher pay in the U.S. is about seventy percent of the pay received by other professionals with comparable education and tenure. In Japan, average teacher pay is equal to that of comparable professionals (Barro, 1987). In absolute terms and taking account of national

differences in purchasing power, teachers in Japan receive at least as much in salary as American teachers and can look forward to far more substantial fringe benefits and retirement income.

Curriculum and Texts. In the old system the central government planned a fixed curriculum for each type of school and supervised the writing and printing of texts for each subject. The Occupation, believing this resulted in excessive uniformity even to the extreme of indoctrination, proposed the relaxation of central authority. Initially, only general curricular goals were authorized leaving to individual school boards and the private sector the task of specifying detailed curricula and preparing texts. However, in the immediate austere condition of postwar Japan where even paper was scarce, this liberalization led to "excessive" waste and duplication, so some tightening up followed.

The central Ministry of Education took the initiative to develop detailed Courses of Study for each school type, allowing generous provision for electives so that each school board could tailor a curriculum suitable to its local needs. In addition, to insure that texts conformed with the Courses of Study, the Ministry established special review committees to inspect and authorize the drafts prepared by commercial publishers.

The outcome of these changes is subject to debate. For most subjects at least five "quality" texts are approved annually by the Ministry's committees allowing local school boards a range of choice; however, those groups who do not share the Ministry's

educational viewpoint often challenge the fairness of the process. Moreover, while local school boards have considerable room to diversify their curriculum, in fact far less occurs than critics feel necessary. Thus while formal control of curriculum and texts was relaxed, in fact the Ministry is felt to exercise enough influence so that schools across the country teach pretty much the same thing.

In the U.S. there are no equivalent central means for developing curriculum or preparing texts, these decisions being left to local school boards and private publishers. However, some would maintain that, due to the influence of accreditation boards and the preferences of key states such as California and Texas, a suprisingly high level of uniformity is achieved in actual offerings across the country. Perhaps the major U.S.-Japan differences lie in what is offered when and who takes advantage of those offerings. As we will illustrate below, focusing on the mathematics and science curricula, the Japanese offerings are more demanding at an earlier stage in the schooling cycle, and Japanese children are far more likely to respond to the challenge than are the Americans.

Primary Education. The new system of Japanese primary schools acquired many of the features of the American elementary school. Primary schools were expected to receive pupils from their immediate neighborhood and to place them in coeducational classes without distinction by ability or other characteristics.

As in the U.S., the curriculum was to extend over six years,

though in Japan each school year was longer (currently 240-plus days in Japan compared with the 180 days typical of the U.S.). The major difference is that the Japanese primary school curriculum offers more than the typical American elementary school with more time devoted to art, music, physical education and language (Kobayashi, 1986).

The number of hours over a school year devoted to mathematics is virtually the same as in American primary schools; however, the Japanese curriculum is more demanding and is uniformly taught to all students in contrast with the U.S. where different levels are taught to different ability groups. Despite or perhaps because of the greater demands placed on Japanese students, they apparently are more successful in mastering elementary level mathematics, for Japanese primary level students routinely outperform Americans on international tests of mathematics achievement (McKnight, 1987). The Japanese science curriculum is structured more systematically, begins at an earlier age, and is offered separately from social science rather than integrated as is the case in many American elementary schools.

Lower Secondary. A major departure of the new system was the extension of compulsory education thrbugh the ninth grade, using the vehicle of the lower secondary school. An immediate concern of postwar educational administrators was the location of buildings and teachers for this essentially new institution. While the Japanese lower secondary school had some resemblance to

the form of the American junior high, there are several differences of interest. Whereas the American junior high usually initiates young people into electives and the selection of teachers, the Japanese lower secondary school is organized much like a primary school, except that the number of students in the same grade level tends to be greater. Admission is based on the neighborhood principle. Entering students are assigned home rooms in such a manner as to mix rather than stratify ability groups, and it is with this home room group that a student takes all of his/her classes. While home room assignments may shift in the second and third years, all students of a common grade level pursue essentially the same curriculum, except for home economics and industrial arts options that are availabe respectively to girls and boys.

By U.S. standards, this common curriculum is demanding; it includes elementary algebra in the seventh grade with exposure to geometry, trignometry, and more advanced algebra topics over the next two years; many American high schools avoid these subjects. The Japanese lower secondary school provides three years of science, social science, Japanese language, English as a foreign language, as well as instruction in fine arts, music, and phyysical education. Teachers move between home rooms over the course of the school day teaching their specialty.

The Structure of Upper Secondary Education. The intent of the Occupation was, following the emerging American model, to foster neighborhood comprehensive high schools which would

receive all of the children from a given geographic area, provide them with a wide choice of elective subjects from both vocational and academic curricula, and thereby allow the young people to develop over the course of the high school an education suited to their needs (Anderson, 1975). The Japanese who were responsible for implementing the Occupation guidelines did simplify the former diverse array of upper secondary institutions, but the final outcome (which has continued to evolve over the postwar period) departed from the Occupations's plans (and hence differs from the "typical" American high school in several respects).

(1) Neighborhood Principle. As school districts in Japan usually contain a larger population in the school-aged cohort than U.S. districts, many had sufficient numbers to allow several public upper secondary schools. The occupation encouraged local districts to implement the neighborhood principle through establishing sub-district boundaries and require all youth within the respective areas to attend the high school specified for that area. Many districts attempted this artificial reform, but their commitment was not strong.

(2) Courses and Curriculum Types rather than Electives. Rather than institute comprehensive high schools, the Japanese authorities decided to define several distinct three year courses and leave to the respective governing bodies (mainly local governments or private sponsors) the decision as to which among these they wished to include in particular high schools. In

contrast with the American system, a student at the point of entry to high school takes up one or the other of these courses, after which time it is difficult to shift to a different course. In a given school, all students taking a particular course will pursue essentially the same sequence of subjects over the three year course. Thus in Japan, student choice is available when selecting the course to study rather than the particular subject to study. The two broad groups of courses are the academic-general and the vocational-specialized; within each group, there are further distinctions.

(a) Academic-General Courses. In the academic-general group are those courses geared for college preparation and those of a more general nature, ostensibly intended to prepare individuals for immediate entry to the labor force; within the academic course, a further important distinction is the curricular branching (often beginning in the second year) between the set of subjects preparing for a science/engineering college major and those preparing for an arts major.

Table 1 about here

Table 1 illustrates the differences in the content of these two branches following the curricular reforms of 1979. Clearly, the students in the science curricular branch receive a more thorough grounding in mathematics and science, but even those specializing in the arts branch receive substantial exposure to math and science; a minority actually make use of that exposure to compete for admission to university faculties specializing in

science and engineering.

(b) Vocational-Specialized Courses. Vocational-specialized courses combine a core of general education subjects with a concentration of specialized courses designed to prepare students for a particular line of work. The general education core at a technical high school includes mathematics I (intermediate algebra with some geometry and trignomety), basic analysis, and calculus as well as science I, physics, and chemistry.

Table 2 about here

The core is rather demanding, and not a few who complete a vocational school find they have sufficient background to compete for entrance to one of the lesser universities.

While there is considerable diversity in the occupational objectives of the specialized group, the courses are commonly grouped into those designed to prepare students for work in agriculture, industry, commerce, fisheries, nursing, and home economics. Iwaki (1985, pp. 9-10) observes that the popularity of most of these courses peaked in the mid-sixties, after which time the enrollments have declined, most dramatically in agriculture and home economics, least in business; nursing is the exception with a peak in the seventies.

Private Upper Secondary Education. Given the burden of establishing a large number of lower secondary schools and the absence of strong immediate social demand for upper secondary school graduates, public authorities initially established places for less than half of the eligible age cohort. Complementing the

public institutions were private institutions, often attached to private universities or other private institutions. Because the public authorities were unwilling to provide sufficient places to accommodate all of the graduates of the lower secondary schools, a demand quickly developed for expansion of the private sector. Private educators were quick to respond; by 1960 their institutions provided half of the places for upper secondary education.

Private schools are required to follow the same course of study as public institutions. The great majority of private institutions are located in urban areas and offer the academic-general courses. Some have a reputation for high quality (that is, large numbers of their graduates get into top universities), but the majority tend to attract students whose records were too low to qualify for the limited number of places in the public sector.

Tertiary Education. Another dramatic proposal of the Occupation was the expansion of public higher education through establishing a public institution in every prefecture and hopefully thereby eleminating the elitist position of the old Imperial Universities. As with other reforms requiring personnel and building budgets, this also encountered difficulties. Most prefectural governments indicated their reluctance to support a university along with their other new burdens. Thus the central government assumed the responsibility for establishing most of the institutions. Through the consolidation of prior upper

secondary and tertiary institions, some semblance of conformity was realized as early as 1949.

Several of the "new" public universities offered instruction in a wide spectrum of academic areas, mainly because they were based on old imperial universities or arts and science faculties. Most, however, were based on combinations of former specialized institutes, as in agriculture or teacher education, and assumed an initial form equal to the sum of these parts. The governments' initial policy was to limit the full development of these lesser universities, rather restricting their expansion to fields felt to have high priority in national development. Engineering was one such field, and thus became very prominent in the new national universities. By 1960, 37 of the 74 national universities had engineering faculties (and 31 had science faculties) (Seki, 1981).

The new laws on university establishment made it much easier for private bodies to found higher educational institutions. A number of long-established private schools sought recognition as universities, while others sought permission to create short-term (tanki) universities with two year courses, similar to American junior colleges. Because of government restraint in establishing places for higher education and the increasing private demand, over time the private sector of private higher education rapidly expanded. In general, the private sector complemented the public sector, emphasizing the humanities and social sciences. Many of the new private institutions were junior colleges.

Exams and the Elite Path. The postwar reformers hoped, through expanding higher education, to create greater competition for the elite universities and thereby to weaken the link between attendance at particular universities and the quality of career prospects. However, given the insecurities of postwar Japan and the doubtful quality of many of the new institutions, both students and employers saw little reason to alter the prewar pattern. The brightest and most ambitious students continued to seek entry to the most highly regarded institutions, which now seemed even more prominent when contrasted with the much larger number of universities, while employers continued to prefer recruits from these top institutions.

The focus of the new system, even more than the old, was the competition to gain entry to the handful of elite universities that enjoyed the confidence of prestigious employers in government and business. The new system, by radically expanding the upper secondary level, provided much larger numbers of young people with the qualifications to seek entry to these elite institutions. To sort out the applicants, the institution of entrance exams was strengthened.

Most of the top institutions of both the public and private sector designed their own unique exam format. Usually, the constitutent faculties of the respective institutions became the examining bodies, but at a given institution a prospective student was restricted to taking the exam of only one faculty.

The emphasis on academic content in the university entrance

exams, combined with the keen ambition of young people, has influenced the lower levels of the system. For example, whereas in the old system upper secondary schools once graduated approximately as many students as there were university places, now there was a surplus. Thus upper secondary schools that aspired to send students upwards encountered the need of carefully selecting their student and then offering a challenging academic program. Similarly, middle schools felt pressure.

One important outcome has been the development of comprehensive (multi-subject) entrance exams at each major passage in the schooling hierarchy. These exams tend to induce student application across all subject areas. Supplementing the entrance exams are several different kinds of aptitude exams administered by private bodies to enable interested students to assay their relative ability. The increasing availability of these various exams combined with the publication of results by schools has sharpened public perceptions concerning which schools do the best job in academic preparation. These perceptions have in turn influenced educational policy.

Tight Education-Work Link. The pressure on students to do well in studies means that other youthful activities receive lower priority. Athletics and social activities are progressively curtailed as young people approach the stage of university entrance; in this context of singular dedication to academic progress, it is socially taboo to drop out for a period

of months or a year to explore other alternatives. Employers organize to recruit those students who decide, at the end of their studies, to seek work. Thus employers seek graduates of the lower secondary, upper secondary, junior college, and university course. As economic conditions strengthened, the job prospects at each of these points of passage improved. By the early sixties, virtually all who graduated could expect jobs.

In sum, a tight link was established between education and work in Japan. Security and full employment were the reward for foregoing freedom and youthful expoloration of alternate life styles. Whereas the unemployment rate of American adolescents often ranges above 20 percent, in Japan since the early sixties it has been virtually nil.

The Pipeline in 1961. The Occupation reforms were largely consolidated by 1961, and subsequent policy has been directed to new ends. 1961 represents a kind of turning point in American education as well, for it was roughly from that time that the post-Sputnik drive for quality began to take root. Hence 1960 is a good baseline point for examining Japan's s/e pipeline. What I will do here is simply summarize the enrollment ratios for the different school levels in 1960. The pipeline experience by actual cohorts would differ due to demographic fluctuations and shifts in educational opportunities.

Figure 1 about here

As illustrated in Figure 1, virtually all of the eligible youth completed primary and lower secondary

education in 1961. 62.3 percent attended upper secondary of which 58.3 per cent were in the academic-general course (sex differences are insignificant for both statistics). While data is not available on the science-arts choice, I will assume about half are in the science course. 15.9 per cent of the males and 5.6 percent of the females attend some form of tertiary educational institution. Most males attend four-year colleges while about the females are divided 50-50 between two and four-year colleges, so about 9 percent attend 4-year colleges. About 90 per cent graduate from their program (nearly all within the expected 4-5 year time period). One third of these specialize in science and engineering, so 3 percent of the cohort moves into the science/engineering pipeline.

The Era of "Miracle Growth" and Educational Expension and Upgrading

From 1961, Japan's economic leaders under the leadership of Prime Minister Ikeda embarked on an ambitious plan or export-oriented growth to double the per capita income in a single decade. At the time the goal seemed unattainable, but in fact it proved an easy task. The rapid economic growth of the sixties was sustained well into the seventies, and even today the Japanese economy continues to expand at least 25 percent more rapidly the economies of other industrial nations. The rapid economic expansion led to full employment and a rapid increase in the number of jobs in medium and large-scale organizations.

Coincidental with the push for rapid economic growth was a sudden increase in the number of young people eligible for work. From 1962 the first cohort of thepost war baby boom began to enter high schools. The public responded to these employment opportunities by encouraging more of their children to consider upper secondary and tertiary education.

Already by 1960, Japan had an impressive educational system at least in terms of quantitative indicators. The S/E pipeline was preparing as large a proportion of the cohort for engineers as the American pipeline, and somewhat less than half the American proportion for scientific careers. In both respects, Japan was already ahead of the major industrial nations of Western Europe.

The dual factors of rapid economic growth and the baby boom interacted with the baseline structure to achieve rapid expansion and upgrading of the S/E pipeline (Kaneko, 1987).

Compulsory Level. From 1961 a new curriculum was introduced which modestly elevated the expected standards for primary and lower secondary education. New schools and classrooms had been established over the fifties to accommodate the baby boom. In 1958, a new law was enacted requiring local governments to provide a science laboratory in each primary and lower secondary school, and related regulations guaranteed a minimum provision of equipment for the laboratories.

Upper Secondary. During the fifties only modest expansion was allowed in the number of places for entrants to public

schools, but in response to the new demographic and economic developments of the sixties steps were taken to expand the industrial and business courses of public upper secondary schools. In addition, from 1962 a new publicly sponsored higher technical college was established combining the three upper secondary years with two additional years of practical education. While public sector expansion focused on the vocational courses, private schools recognizing the popular demand for academic course education rapidly expanded academic course offerings. Eventually, the public sector followed the private lead, modestly increasing its number of academic track places. Curricular reforms implemented in 1963 and 1973 increased the expected standards of performance.

Figure 2 about here

Figure 2 illustrates the trends in number of places by course. School expansion, which mainly involved the academic track, was much in excess of the growth in cohort size; thus over the 1960-1980 period, the upper secondary enrollment rate increased from 54.9 percent to 92.9 percent. With Japan's custom of automatic promotion, virtually all who are enrolled graduate. Japan's 90 percent level for high school graduates compares favorably with the U.S. where only six-tenths of the cohort graduate on schedule, and no more than 85 percent of the cohort eventually obtain a high school diploma.

Increasing the Size of School Districts. As in the U.S., the majority of public upper secondary schools are managed by local

authorities, but relative to the U.S., Japan's local authorities tend to be responsible for larger areas, at least if measured by population. Thus it is common in Japan for a local authority to be responsible for several upper secondary schools.

Initially local authorities established geographic divisions so as to realize the neighborhood principle. But in many instances this change eliminated the possibility for parents to send their children to nearby schools that had been reknowned in the old system for their success in grooming candidates for the top universities. Parents objected, and when public authorities would not compromise, many of these parents elected to send their children to reputable private upper secondary schools rather than risk the education offered by the neighborhood school. So gradually a counter-reform evolved combining all of the high schools of a distict in a hierarchical system, and assigning lower secondary graduates into the upper secondary schools according to their ability. This approach, which has obvious parallels to the magnet schools established in certain U.S. urban areas, tended to appease the Japanese public. One obvious outcome was to intensify the effort among lower secondary level students to study hard so as to qualify for entry to the top public upper secondary school in their district. On the other hand, the stratification of student placement by ability probably has contributed to a greater overall dispersion in the ability of secondary level students.

U.S.-Japan Comparisons of Secondary Level Education. Given

the complexity and diversity in high school offerings both in Japan and the U.S., cross-national comparisons are difficult. Victor Kobayashi (1986) has attempted a comprehensive analysis of the minimum amount of class time (in clock hours) required to graduate from high school in the two systems. His computations for the Japanese case hold for all students in both the academic-general and vocational courses, and were calculated by combining the requirements for the last year of lower secondary school (ninth grade which in the American system is usually part of high school) and the three upper secondary years. Focusing only on the minimum requirement, the contrast is 3,150 hours in Japan compared with the U.S. average across states of 2,100 hours; the Japanese minimum requirements are significantly greater in mathematics, science, physical education and health, and art/music.

For a different perspective on the U.S. experience, Kobayashi next draws on U.S. surveys of units actually earned. He finds that "the average number of units earned by U.S. high school graduates in 1982 was 2,616 clock hours, as compared with the 3,150 classroom hours that are minimally required of all Japanese high school students: a difference of 534 clock hours" (Kobayashi, 1986, p. 86). A further computation indicates that the average U.S. college-bound youth also spent less time in class than is minimally required in Japan. Of course, most Japanese high school students spend far more time in class than is minimally required. Thus Kobayashi concludes that Japanese

students spend more time in class than their American counterparts. He then goes on to argue that classroom time is more efficiently used in Japan, and hence Japanese students learn more. How much more?

Rohlen (1983) has suggested the difference is of such a magnitude that the college-bound Japanese high school graduate already knows more than the average U.S. college graduate. This may be an overstatement. One objective indication of the difference comes from the IEA surveys. The mathematics surveys, which have now been fully released, indicate for 1980 that 12 percent of Japanese high school seniors studied calculus compared with slightly over one per cent in the U.S. The IEA achievement tests administered to these two elite groups (12 percent of Japanese seniors and one per cent of American seniors) indicate that the Japanese average is considerably ahead of the American, 67 out of a hundred compared with 48 for the U.S. Similar differentials have been revealed in preliminary reports from the IEA science surveys (Suter, 1987).

Many of the questions in the 1980 mathematics achievement test had also been given to equivalent school populations in 1964. For these common questions, the average score for Japanese 12th grades in 1980 was 12 percent greater than in 1964. The improvement in the U.S.case was 5 percent (Cummings, 1986, p. 118).

Japanese superiority in international achievement tests has been so consistently demonstrated that there can be little doubt

that more is learned there. A key component in the high average scores of Japanese young people is the relatively small number receiving low scores, at least through the lower secondary level. In other words, Japanese education appears to convey math and science concepts to a larger proportion of the cohort than does American education.

Tertiary Education. Expansion of tertiary education in Japan has tended to follow the pattern of secondary education. Public authorities have been reluctant to acknowledge the value of mass higher education, believing the state's responsibility should be limited to expansion in specific areas essential for economic development, primarily engineering and related specialties. Thus public sector expansion has proceeded at a moderate pace, and overwhelmingly in science and engineering fields. In contrast, the private sector has readily acknowledged the value of higher education and has rapidly expanded to meet the popular demand. Initial private expansion was fastest at the junior college level but subsequently shifted to four-year institutions.

To cover the costs of expansion, private institutions steadily increased their tuitions until they were besieged in the late sixties by student protests and lockouts that occasionally were violent. In response to this situation, the national government decided to recognize the public value of private education and established a Private School Promotion Foundation to provide substantial subsidies to private institutions. The Foundation, which receives nearly all of its revenues from the

national government, awards subsidies based primarily on estimate of the personnel costs of individual institutions; this approach was chosen so as to reward those private institutions with low student-teacher ratios (which coincidentally are the institutions with stronger S/E commitments). The Foundation's subsidies ccurrently constitute about 30 percent of the revenues of private institutions (Cummings, 1973).

Table 3 about here

Despite the subsidies, the financial state of private institutions is inferior to the public institutions. Table 3 presents several comparative indicators. Private institutions are sometimes said to have 1/3rd of the resources of public institutions.

Figure 3 about here

Through the combination of public and private sector expansion, Japanese higher education has steadily increased enrollments, as illustrated in Figure 3. Kaneko observes that Japanese expansion has been of greater magnitude than in Europe or the U.S., and, moreover, has endured longer; whereas the enrollment ratios of the other leading industrial societies peaked in the mid-seventies, Japanese expansion continued through the early eighties.

Table 4 about here

Relative to the size of its college age population, Japan's system of undergraduate education is among the largest in the world. As illustrated in Table 4, the Japanese ratio of first

university degrees as a proportion of the 22 year old population exceeds that of all other countries except the United States, which has an identical ratio.

Figure 4 about here

Relative to the United States, Japanese higher education, as shown in Figure 4, graduates similar proportions in the physical and life sciences,a smaller proportion in the mathematical sciences, over twice the U.S. proportion in the agricultural sciences, and about three times the U.S. proportion in engineering. Especially notable is the large proportion of Japanese students graduating in engineering.

Japan, with about half the U.S. proportion, began to exceed the United States in the granting of first-degree engineering degrees in 1976 and retained the lead through 1982. While figures on engineering degrees by detailed field are not available, it is possible to compare enrollments. As indicated in Table 5, a substantially larger proportion of Japanese engineering undergraduates are enrolled in the fields of electrical and computing engineering and civil engineering and architecture. U.S. enrollents are proportionately larger in the fields of aeronautic, nuclear, mining, and "other" (mainly general) engineering. The two countries have essentially identical proportions in the fields of mechanical, chemical and textile, industrial, and materials engineering.

Table 5 about here

The overall size of undergraduate enrollments began to

stabilize in the mid-seventies, and, largely due to a decrease in the size of the college age cohort, enrollments are expected to decline. In the context of slow growth in enrollments, the shifts in admissions reported in Table 6 provide a useful indicator of future directions for Japanese higher education. Life science fields are most evident among the high growth fields at both the first degree and masters levels. More traditional engineering fields (e.g. marine, textile, mechanical) and core social science fields have been losing enrollments.

Table 6 about here

Parallel to these changes at the first-degree level is a transformation in the nature of courses offered by junior colleges and other post-secondary institutions (kakusho gakko and senshu gakko, which offer shorter cycle courses). The most popular new specialties are in such fields as information processing, laboratory technician, electronics, and international relations.

Education beyond the bachelors level in Japan is usually viewed as preparation for an academic career, and is organized somewhat along European lines. Prospective graduate students, while they make take entrance exams to graduate programs, usually first seek the encouragement of a particular professor that they admire and hope to work with. Once admitted the graduate student tends to look on this professor as his guardian. Given the narrow purpose of graduate education and the particularistic mode of relations, it has not achieved large scale in comparison with

the United States and most European societies. Japan's ratio of masters enrollments to undergraduate enrollments is one-third that of the United States and one half as large as for the leading European societies. Similar differences can be observed for doctoral course enrollments (Ministry of Education, 1984).

However, these statistics may not fully reflect the number of Japanese researchers receiving some form of graduate education. Many of Japan's scientists and engineers leave the university for industry or other employment immediately upon completion of their first degree. While pursuing a career at a new location, they usually maintain contact with their former professor. If and when they complete a research project that meets with the professor's approval, they may submit a report as a basis for obtaining a thesis degree (ronbun hakase). 60 percent of the science and engineering doctorates granted in 1984 were on this basis (Kagaku Gijitsucho, 1986a, p. 119)

The major constraint on graduate enrollment is the lack of associated employment opportunities. For example, in 1983, 51.0 percent of science and 44.9 percent of agricultural doctoral course graduates could not obtain jobs (Kobayashi et al, 1985; also see Yamada, 1982). However, this situation is expected to change. Over the past two decades, the employment opportunities for masters level engineers have improved and they have become a virtual majority of all masters students. At the doctoral level the most popular fields are medicine and dentistry. The Japanese Ministry of Education would like to see more students enrolled in

graduate education, and thus has announced a plan that would lead to a three-fold increase in masters level enrollments and a fourfold increase in doctoral enrollments by the year 2000 (Ministry of Education, 1984).

Consideration of graduate education is not complete without an appreciation of the rapidity with which Japanese expenditures on research and development have grown over the past decade, and of their future prospects. Between 1965 and 1984, Japanese research and development expenditures (converted with OECD deflators and purchasing power parities into U.S. dollars) increased at an average annual rate of 9.3 percent compared to the U.S.'s 2.5 percent. As a percent of GNP, Japanese expenditures increased from less than one percent to 2.6 percent in 1984, or about the U.S. level. Japanese planners propose a futher expansion to 3.3 percent by 1995. (Cummings, 1986b). These trends in research and development expenditure are the grounds for anticipating expanding employment opportunities for the products of graduate education.

Traditionally, foreign students have constituted an exceptionally small proportion of Japanese enrollments at all degree levels. In 1982, foreign students were only one-half a percent of all student in Japanese higher education compared with 3 percent in the U.S. and from 4-10 percent in the leading European societies. At the graduate level, foreign students in Japan constitute approximately seven percent of the enrollment. In 1984 the Ministry of Education announced a plan to increase

the number of foreign students tenfold by the year 2000 (Mombusho, 1984). If this were to take place, foreign students would constitute approximately five percent of all students in Japanese higher education, and possibly one-quarter of all graduate students. Currently, foreign students of Western origin are most likely to specialize in the humanities and social sciences while those from Asia and the third world are most likely to specialize in the sciences and engineering. In the absence of new policies, these trends of regional specialization will most probably continue.

The Pipeline in 1985

The past quarter century has resulted in a much broader S/E pipeline, which can be appreciated through comparing Figure 5 below with Figure 2 presented earlier. Virtually the entire age cohort completes high school, with over two thirds in academic high schools; about one-half of these students are in science courses. Over one fifth of the cohort attend four-year universities, with about three of every ten specializing in a science or engineering field. In 1985, about six percent of the cohort is prepared for a career in science and enginneering compared with the three percent of 1960. Over the twenty five year period, the U.S. pipeline has fluctuated around a three percent level. Thus over the past quarter century Japan has doubled its level of preparation while the U.S. has evidenced no significant change.

Figure 5 about here

The Japanese Policy Mechanism and the Future

Science and Technology Policy is coming to be viewed with increasing importance in Japanese society as the economy comes to depend more on high technology production and enters into direct competition with the other advanced societies. Moreover, for the sake of national pride, Japan which has long looked to the West for scientific leadership and technical innovation, now wishes to return the debt and gain new recognition.

These sentiments are echoed by a variety of sources. Business leaders are devoting ever larger sums of money to their corporate R&D budgets, and stepping up the pressure on government for new initiates. Politicians became so caught up in the new vision that they supported the launching of the Science and Technology Expo at Tsukaba Science City from 1984-85.

Concerning national science and technology policy, there are several contenders who seek to advance special initiatives; however, the Prime Minister's Science and Technology Council has emerged as the most prominent among them. In 1986, the Council published its 11th Recommendation calling for increased emphasis on fundamental research:

> Japan will no longer have any model in the world to lead her future. Therefore, it is absolutely necessary for Japan to make efforts, trials, and even errors. That means Japan will have no way to ensure the development

of the nation, without plentiful stocks of fundamental basic research activities (Council, 1984, p. 2)

The report goes on to stress the importance of "promoting creativeness in science and technology" though placing greater emphasis on fundamental research and through strengthening interaction with scientists from other nations.

While some of the Council's aims can be realized through dependence on the current stock of scientists and engineers, Japan's leaders are keely aware that the current S/E work force was educated in a system that stressed conformity over uniformity, and moreover, that the current work force is aging, especially in the sciences. Hence the urgent need to look ahead. But as the vision turns to the new generation there are other problems: the size of cohorts is decreasing, the will to work is waning, and above all, the education system stifles the very creative qualities needed for fundamental research (Motoguchi, 1986).

Hence, contemporaneous with the Science and Technology Council's Recommendation was the Prime Minister's decision to form a high-level National Council on Educational Reform. This Council has been meeting over the past three years and in September of 1987 will issue its final report. The broad outlines of this report are already evident (National Council on Educational Refom, 1985, 1986, 1987). As in the Science and Technology Council's 11th Recommendation, a paramount concern is to introduce greater diversity in the school system and thereby

hopefully to stimulate more creativity among those so gifted. More attention to ability grouping is urged, and at the secondary level, the National Council suggests that some local councils consider combining lower and upper secondary schools into single institutions that pursue a more integrated program of study that can shield young people from the distractions of exam preparation.

Other proposals of the National Council are to

--Add a year of supervised teaching to teacher training. The Council believes that more guidance needs to be given new teachers, as well as more care should be exercised before job security as a teacher is guaranteed.

--Strengthen undergraduate education. The Council subscribes to the view the undergraduate educational system is unstimulating at best, more often an outright waste.

--Establish more structure in graduate education, and significantly expand graduate education. Here the Council seems to be advocating a systematic program of education along U.S. lines; it anticipates a growing demand for individuals with advanced scientific, technical, and analytic skills.

--Establish more opportunities for post-doctoral research

fellowships. A small program has been underway for several years, and the Council feels this should be expanded. To the extent possible, the Council advocates that post-doctoral fellows be given broad freedom to pursue sustained research of their own choosing so as to fully realize their creative potential.

--Improve the research environment in universities. The Council points to many factors including the shortage of funds, the hierarchical relations among university staff due to the antiquated chair system, excessive inbreeding (at several of the top universities, over 80 percent of the staff are former students), the scarcity of colleagues due to the small size of many departments.

--Facilitate university-industry ties in research and training. The Council is aware that industry has vast resources to support research as well as much outstanding talent, and thus proposes that new avenues be established to enable university research teams to draw on these resources and reciprocally for industry to make use of the fine brains and facilities found in the universities. Since World War II, due both to the horrors associated with wartime collaboration with industry and out a firm belief that Japanese society needs an autonomous university sector for the preservation of democratic values, has resisted formal cooperation with both government and business.

--Internationalize Japanese education and research through increasing the number of foreign students on Japanese university campuses and through supporting an increased level of interaction between Japanese and foreign scientists. Among other reasons, the Council recognizes that new points of view will stimulate Japanese research onto new creative heights.

It is certain that the Japanese system will undergo substantial change over the coming years.

Reflections

The Japanese system, if viewed comparatively in terms of quantitative indicators, appears well-prepared for the coming decades when economic strength will depend, above all, on those who are both able to develop new scientific and technical insights and to translate these insights into practical solutions. Processes have been set into motion to provide the Japanese work force with a plentiful supply of such people. What is behind the Japanese story?

1. Postwar reforms. At the core of the Japanese story are those reforms introduced immediately after World War II which eliminated the numerous tracks and established a uniform system of education for all through the ninth grade. Some of these changes had been sought by Japanese educators long before the Occupation, but they would not have been possible without this unprecedented interruption of normal government.

2. Firm national leadership. Much of the postwar story involves a steady pursuit of long-standing commitments through firm central government. The faith in science and entineering has been realized through steady annual budgetary increments and modest changes in former practices, rarely through radical leaps forward.

3. Science and engineering as a core commitment. Since the Meiji restoration, Japan's leaders have demonstrated an unswerving belief that development depends on creating industrial strength, which in turn requires an extensive science and engineering work force. Policies of educational expansion and curriculum change have consistently reflected this commitment.

4. Practice of anticipating S/E demand. The Japanese faith in science and engineering has led policy makers to push the expansion of programs and disciplines in the absence of clear demand. The expansion of engineering in the sixties was based on the assumption that engineers would be important rather than on clear market demand. Similarly, the current expansion of graduate and postgraduate education is based on a vision of the society to be, rather than current indicators. This forward view has usually proved prescient, thanks to the coordination of different sectors and the continuing forward thrust of the Japanese economy.

5. Creating S/E demand. In the early stages of these forward thrusts, demand is sometimes created for the new graduates. For example, currently the government is establishing a number of new

university-industry collaborative research programs that require post-graduate researchers in a seeming effort to stimulate industry demand for research personnel with advanced training.

6. Essentialist Curriculum. Japanese educational philosophy stresses the importance of mastering key subjects, rather than responding to innate idiosyncracies of individuals. Only with mastery of fundamentals can the individual expect to realize creativity. Thus the curriculum requires all young people to study the essentials of math, science, and foreign languages with few electives. Entrance exams to each successive level are based on what students know rather than aptitude, thus rewarding hard study and mastery over innate intelligence.

7. Hierarchical educational system. The Japanese policy makers seem to prefer a system where differential value is attached to respective secondary and tertiary institutions. In this hierarchical system, going to college is not enough. Rather young people know that it makes a difference which college they go to. Hence, they feel pressure to study hard and strive to do their best, recognizing that most others in their cohort are also making the same effort.

8. Reliance on private sector. For secondary initiatives, the government has shown a willingness to tolerate and even encourage the private sector through subsidies when it serves a public purpose. Currently the private sector is establishing a number of training schools that will assist the established labor force and new recruits to obtain proficienty in computer-related

skills that the government believes are not appropriately taught in the essentialist oriented formal educational system.

Underlying the steady expansion of Japanese education is a strong public faith that success in schcoling leads to a secure adult career. Employers confirm this faith through their recruitment of graduates straight from school, and their commitment to continue employing these recruits until they either resign or retire. The Japanese work contract emphasizing stability and security pervades all walks of life including the universities and research laboratories. This strength of the Japanese system is also its major weakness. It induces a penchant towards conformity and uniformity that sometimes conflicts with the creativity and initiative required in the best scientific and technical work. Thus, a major concern in the present reforms is to bring greater flexibility and instability to a system that is premised on limited choice and stability. Japan's challenge is to identify the structural reforms required to reverse the traditional pattern. The current concern to expand graduate education, break down the traditional chair system, expand university-industry-government collaboration, and increase the number of foreign researchers in Japanese laboratories is all part of the thrust for a new more stimulating pattern of organization.

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Figure 1 Progression Rates
in the Japanese Educational System, 1961

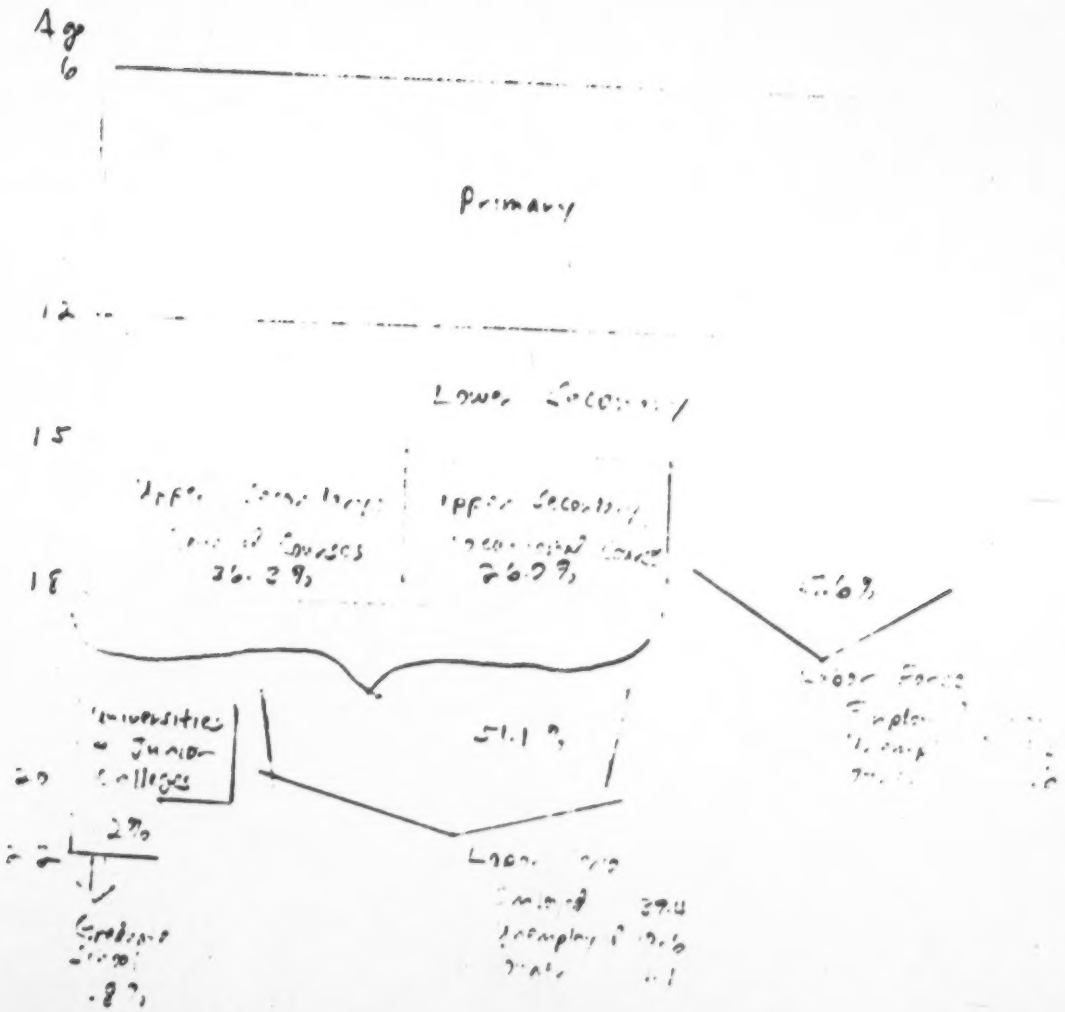


Figure 2. Number Students in General and Vocational Courses

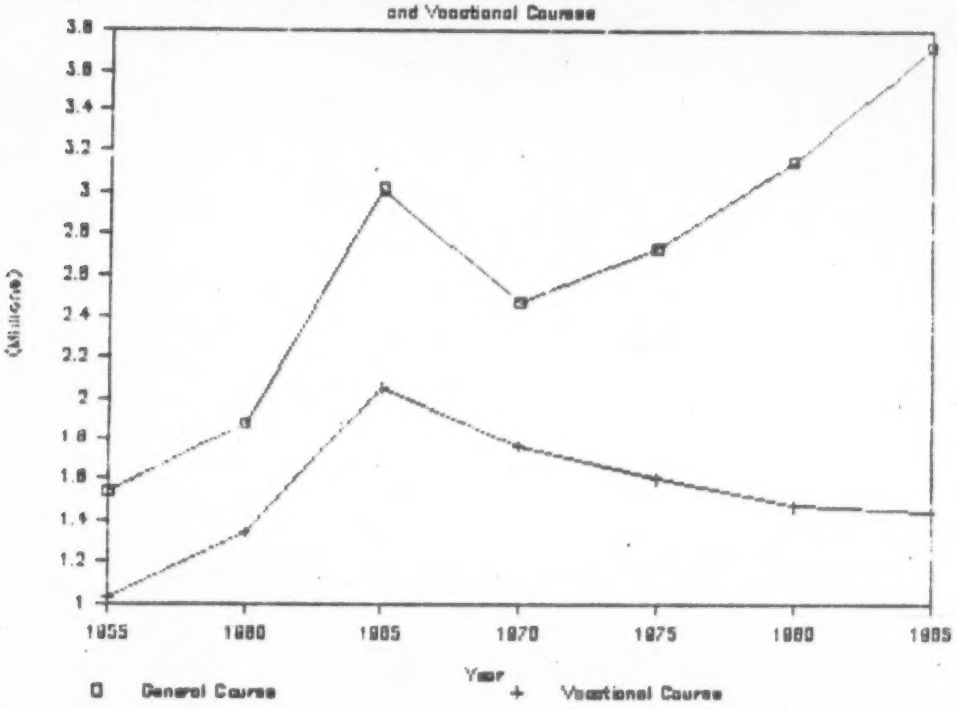
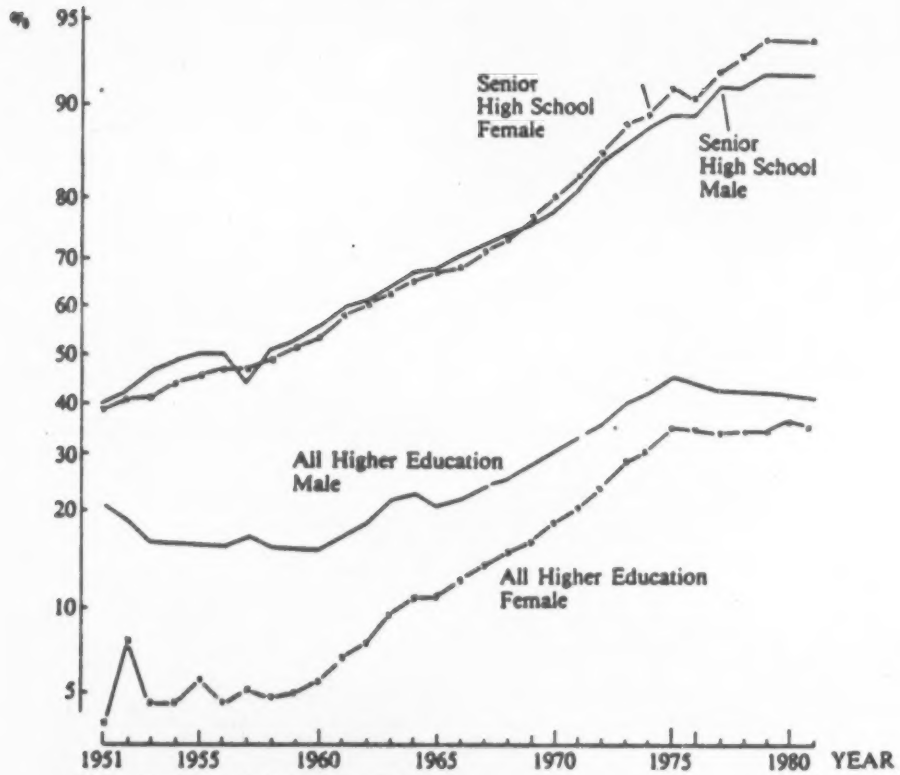


Figure 3. Cohort Enrollment Rates in Japan, 1951-1981

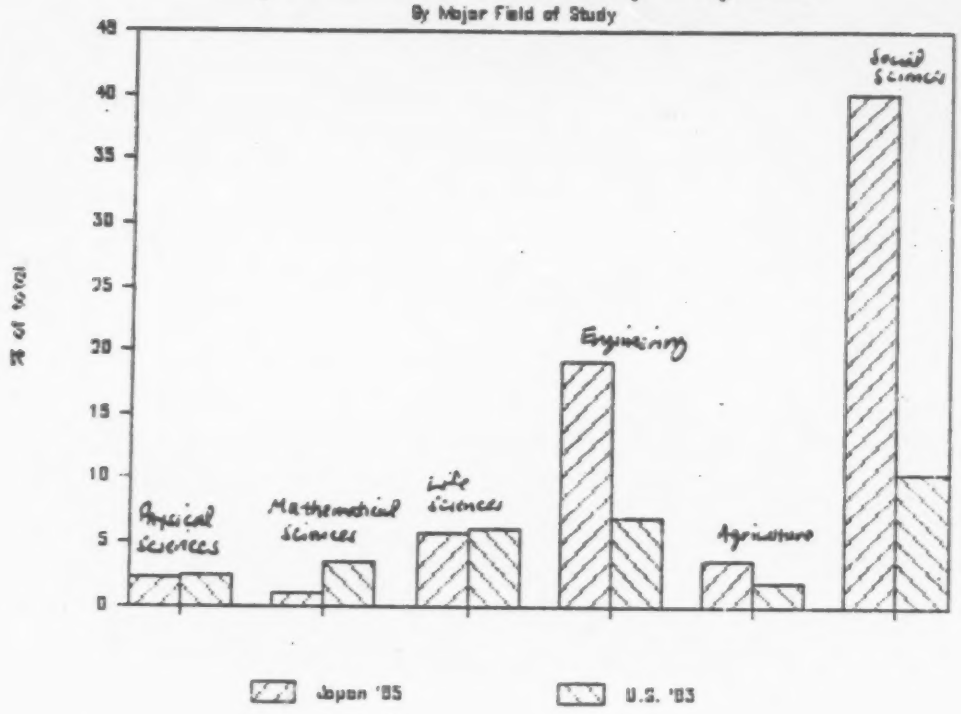


Note: Vertical axis is logit-transformed.

Source: M. Kaneko, Enrollment Expansion in Postwar Japan, p. 2.

Figure 4. First University Degrees

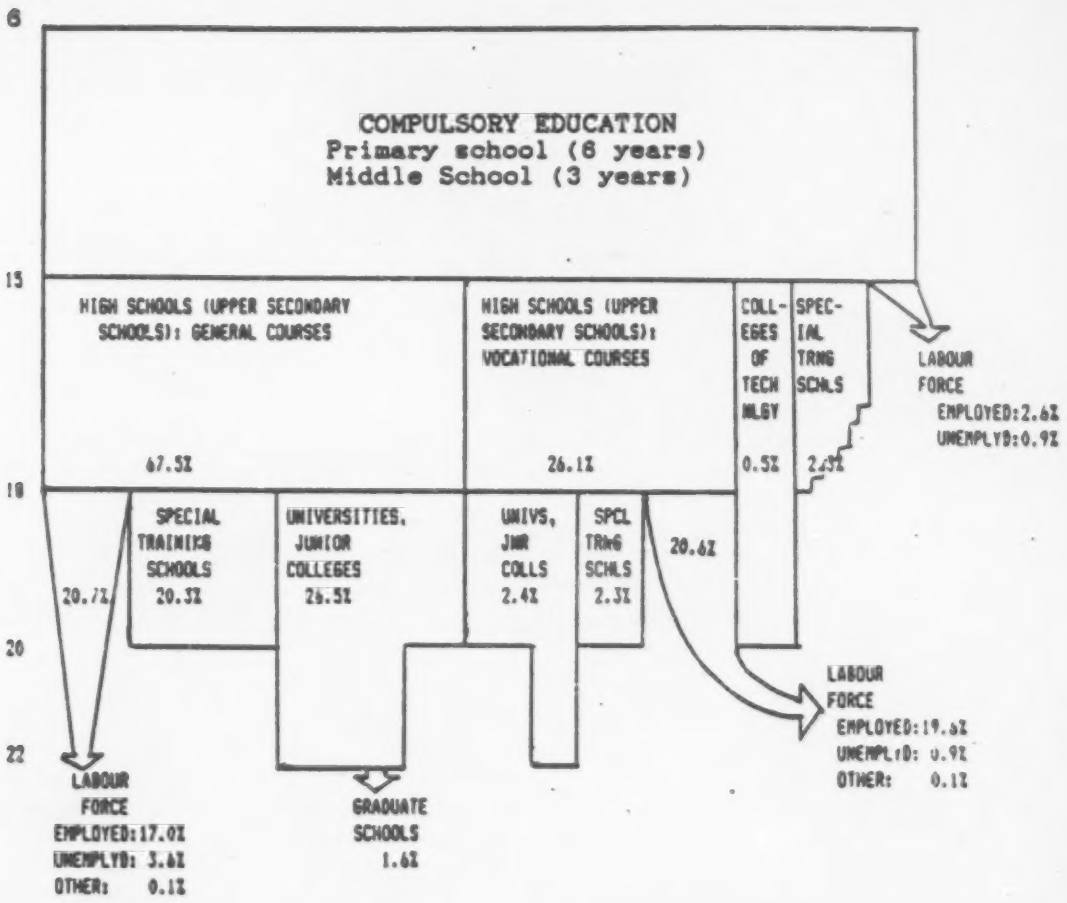
By Major Field of Study



Sources: NSF, Ministry of Education

Note: U.S. data for 1983, 81.3% = other fields not shown
Japanese data for 1985; 28.3% = other fields not shown.

FIGURE 5 PROGRESSION RATES IN THE JAPANESE EDUCATIONAL SYSTEM, 1985



Special Training Schools (senshu-gakko) proper, also miscellaneous schools, [illegible] (shokugyo kunrenko).

SOURCE: Ministry of Education, Science and Culture.
Monbu Tokei Yoran, 1986

TABLE 1. SENIOR HIGH SCHOOL COURSE TIME TABLES

a. Credit requirements for Students who wish to advance to arts departments of universities

Subject area	Subjects	Grade 10th	Grade 11th	Grade 12th	Total credits
Japanese Language	Japanese Language I	5			5
	Japanese Language II		5		5
	Modern Japanese Language			3	3
	Classics			3	3
Social Studies	Contemporary Society	4			4
	Japanese History				
	World History		○○ (3×2)	○○ (2×2)	10
	Geography				
	Politics and Economy			2	2
Mathematics	Mathematics I	5			5
	Algebra & Geometry		3	3	6
	Basic Analysis		2	2	4
Science	Science I	4			4
	Science II			2	2
	Chemistry		3	2	5
	Biology				
Health and Physical Education	Physical Education	2	2	3	7
	Health	1	1		2
Art	Music I				
	Fine Arts I	2	1		3
	Calligraphy I				
Foreign Language	English I	5			5
	English II		2	3	5
	English II B		3		3
	English II C			4	4
Home Economics	General Home Economics	2	2		4
Additional credits		2	2	2	6
Total for all subjects		33	33	33	98
Homeroom activities		1	1	1	3
Club activities		1	1	1	3
GRAND TOTAL		34	34	34	102

* Six credits from two subjects from among Japanese History, World History and Geography (**three credits for each subject).

** Four credits in two subjects from among Japanese History, World History and Geography (two credits for each subject).

b. Credit requirements for students who wish to advance to science departments of universities

Subject area	Subjects	Grade 10th	Grade 11th	Grade 12th	Total credits
Japanese Language	Japanese Language I	5			5
	Japanese Language II		4		4
	Modern Japanese Language			4	4
Social Studies	Contemporary Society	4			4
	Japanese History		3	3	6
	Geography				
	Politics and Economy			2	2
Mathematics	Mathematics I	5			5
	Algebra & Geometry		3	2	5
	Basic Analysis				
	Differential and Integral Calculus			3	3
Science	Science I	4			4
	Physics		3	3	6
	Chemistry		3	3	6
Health and Physical Education	Physical Education	2	2	3	7
	Health	1	1		2
Art	Music I				
	Fine Arts I	2	1		3
	Calligraphy I				
Foreign Language	English I	5			5
	English II		2	3	5
	English II B		3		3
	English II C			3	3
Home Economics	General Home Economics	2	2		4
Additional credits		2	2	2	6
Total for all subjects		33	33	33	98
Homeroom activities		1	1	1	3
Club activities		1	1	1	3
GRAND TOTAL		34	34	34	102

SOURCE: National Institute of Educational Research, Basic Facts and Figures about the Educational System in Japan, Dec. 1983

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TABLE 2. CURRICULUM AT A TECHNICAL HIGH SCHOOL

(Unit: credit = 35 (50-minute) hours)

Subject area	Subject	Year 1	Year 2	Year3	Total
Japanese language	Japanese Language I	4			4
			2	3	5
Social Studies	Contemporary society	2	2		
	World history				
	Geography			2	2
Mathematics	Mathematics I	4			4
	Basic analysis		3		3
	Differentiation and integration			2	2
Science	Science I	4			4
	Physics		2		2
	Chemistry		2		2
P.E.	Physical Education	2	2	3	7
	Health	1	1		2
Art	Music I/Art I	2			2
English	English I	3			2
	English II		3		3
GENERAL SUBJECTS: TOTAL:		22	17	13	52

VOCATIONAL SUBJECTS

Subject	Engineering Course				Electrical course			
	Year 1	Year 2	Year 3	Total	Year 1	Year 2	Year 3	Total
Fundamentals of Industry	4			4	3			3
Practice		4	4	8		4	6	10
Drawing	3	3	4	10		2	2	4
Industrial mathematics	2			2	2			2
Machine engineering work		2	2	4				
Machine design	1	2	3	6				
Prime movers		2	2	4				
Basic electricity		2		2	5	3		8
Electrical technology I						3	4	7
Electrical technology II						3	3	6
VOCATIONAL TOTALS				40				40

Up to 4 optional credits may be taken from either the general or the vocational menu

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Table 3. Educational Conditions in National-Public and Private Universities (recent years)

Condition	National-Public Universities	Private Universities
Expenditures per student (1000 yen)	220.0	87.9
Building area per student (square meters)	31.3	13.0
Campus area per student (square meters)	111.8	68.8
Students per full-time Teaching staff member	8.1	25.4

Source: Nippon Shiritsu Daigaku Renmei (1984, p. 16)

Table 4

First University Degrees as a proportion of the 22 Year Old Age Population

	Number of Degrees	Percent of 22 Year Olds
United States (1983)		
Total	1,054,200	23.4%
Natural Sciences	104,800	2.3%
Engineering	72,900	1.2%
Agriculture	19,200	0.4%
Other	857,300	19.0%
Japan (1983)		
Total	369,100	23.6%
Natural Sciences	11,700	0.7%
Engineering	69,600	4.5%
Agriculture	13,300	0.9%
Other	274,500	17.6%
West Germany (1983)		
Total	54,800	5.3%
Natural Sciences	8,900	0.9%
Engineering	7,700	0.7%
Agriculture	2,100	0.2%
Other	36,100	3.5%
United Kingdom (1983)		
Total	74,100	8.1%
Natural Sciences	17,400	1.9%
Engineering	10,600	1.2%
Agriculture	1,400	0.2%
Other	274,500	30.0%
France (1983)		
Total	44,600	5.2%
Natural Sciences	8,700	1.0%
Engineering	12,600	1.5%
Agriculture		
Other	23,300	2.7%
Soviet Union (1983)		
Total	849,500	17.0%
Natural Sciences	52,000	1.0%
Engineering	331,500	6.6%
Agriculture	[illegible]	[illegible]
Other	396,800	7.9%

NOTE: French agricultural degrees are included with natural sciences

SOURCES: National Science Foundation, U.S. Bureau of the Census and national sources listed in first degree table.

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Table 5. Japan-U.S. Comparison of Enrollments in First Degree Engineering Programs

	Japan '84		U.S. '83	
	Number	Percent	Number	Percent
Mechanical	73674	21.5%	71459	19.9%
Electrical & Computing	100105	29.2%	85513	23.8%
Civil Engineering, Architecture	76986	22.5%	41234	11.5%
Chemical & Textile	41876	12.2%	36992	10.3%
Nuclear	1542	0.5%	2071	0.6%
Mining	1569	0.5%	4004	1.1%
Metalurgical & Materials	7243	2.1%	4811	1.3%
Marine	1015	0.3%	2847	0.8%
Aeronautic	2319	0.7%	14115	3.9%
Industrial	19928	5.8%	22549	6.3%
Other	16199	4.7%	73769	20.5%
Total	342456	100.0%	359364	100.0%

Source: Monbusho, Gakko Kihon Chosa 1984 (note only full-time studies;
Engineering Manpower Commission of the American Association of Engineering Societies, Inc. Engineering and Technology Enrollments Fall 1983
Part 1 Engineering Total Full-time Studies (note some are in two-year programs)

Table 16. Science and Engineering Fields with 10% or Greater Shift in Number Admitted Between 1975 and 1983

All Universities	Admissions to First-Degree Programs	Admissions to Master's Programs
Geology	+57%	
Biology	+51%	
Mathematics	+29%	
Chemistry	+16%	
Nursing	+14%	
Physics	+13%	
Pharmacy	+12%	
Dentistry	+11%	
Commerce and Economics	-12%	
Law and Political Science	-14%	
Agricultural Economics	-16%	
Textile Engineering	-35%	
Marine Engineering	-50%	
Veterinary Science		380%
Pharmacy		78%
Nuclear Physics		70%
Electrical Engineering		57%
Aeronautical Engineering		45%
Forestry Products		38%
Chemistry		39%
Civil Engineering & Architecture		34%
Irrigation Engineering		34%
Applied Physics		34%
Physics		33%
Geology		30%
Applied Chemistry		28%
Mathematics		25%
Agricultural Chemistry		20%
Biology		19%
Mechanical Engineering		18%
Law and Political Science		-15%
Sociology		-20%